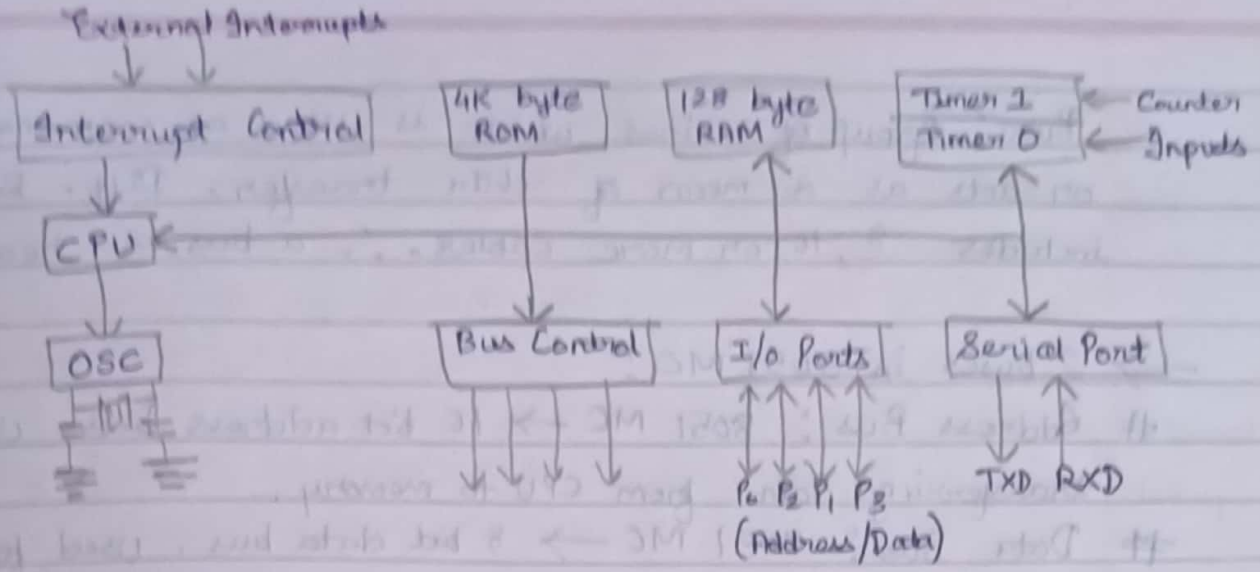
EIoT

8051 Microcontroller : • Invented in 1980's by Intel.
• Foundation based on Harvard Architecture & developed for use in Embedded System.
• First created using NMOS technology but use of NMOS (N-channal metal oxide semiconductor) consumed more power therefore Intel re-launched the microcontroller using 8051 using CMOS (complementary metal oxide semiconductor) and new addition came up with edition of letter 'C' in title name. Hence called 80C51. Microcontroller 8051 program is performed in embedded C language using Keil software.

Four Register Banks → 128 user defined flags
64 K bytes ROM → 16 bit timers
128 k bytes RAM → 32 general purpose registers each of 8 bit
Address bus is 16-bit unidirectional
Data bus is 8-bit bidirectional.

on: → Home Automation : Controls lighting, temperature, security
Industrial Control: Controls processors, machinery, pressure.
Robotics: Control movement of robots, sensors, actuators.
Communication devices: Used for data transmission, signal processing.
Consumer electronics: Used in remote control, digital cameras.

cture:
8051 - series of 8-bit microcontrollers
2nd generation of 8-bit microcontrollers.
Contains Boolean processor, full duplex serial port and power saving circuitry, 8-bit CPU, timer/counter & parallel I/O lines.



* Interrupt : Sub-call routine given by MC when other program with high priority requests for acquiring the system buses. It provides a method to postpone/delay the current process, performs a sub-routine task & restart the std. program again.

→ Five Sources of interrupt :

- Timer 0 overflow — TF0
- Timer 0 overflow — TF1
- External hardware Interrupt — INT 0
- External hardware Interrupt — INT 1
- Serial Communication Interrupt — RI/TI

* IP (Interrupt Priority Register)

- Priority levels of interrupt can be changed by changing corresponding bit in IP register.
- Low priority interrupt can only be interrupted by high priority interrupt
- If 2 interrupt (diff. priority) received simultaneously, request of higher priority will be served.
- If requests of same priority levels received simultaneously, then internal polling sequence determines which request is to be serviced.

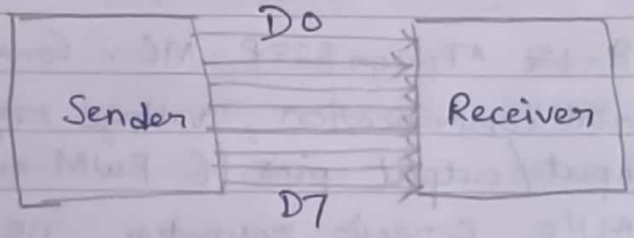
Counter	Timer
• Register is incremented considering together 1 to 0 transitions as its corresponding to an external input pin (T0, T1)	• Register incremented for every machine cycle.
• A counter uses an external signal to count pulses.	• Timer uses frequency of internal clock signal and generates delay.
• Max count rate is 1/24 of oscillator frequency	• Max count rate is 1/12 of oscillator frequency.

* Serial Communication : 2 ways

⇒ Serial transfer : Data transferred to device located many metres away. Used for long distance data transfer.

Sender → Receiver

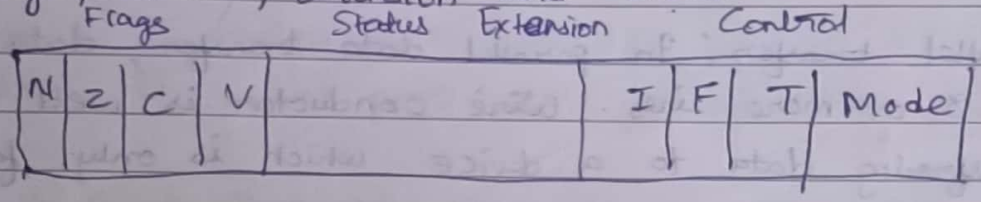
⇒ Parallel transfer : In parallel data transfer, data transferred in 8 or more lines. Wire conductor is used for transferring data to a device which is only few feet away.



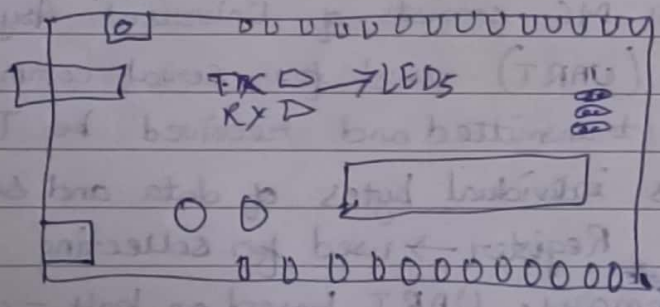
• Serial Communication – Used for transmitting and receiving signal. 8051 MC consists of Universal Asynchronous Receiver Transmitter (UART) used for serial communication. Signal are transmitted and received by Tx and Rx pins of MC. UART takes individual bytes of data and sends individual bits in sequence. Register → used for collecting and storing data inside a memory. UART based on half-duplex protocol. It means transferring and receiving data but not at same time.

* ARM Architecture: Advanced RISC Machines. 32 bit Reduced Instruction Set Computer (RISC) Load store architecture. 1st RISC micro processor for commercial use. It is a cost sensitive embedded applications. ARM is based on Von Neuman Architecture and it is a load/store architecture. 32 bit data bus for both instruction and data. In ARM core functional units connected by data bus, arrow represent flow of data, lines represent buses, boxes represent operation unit, 18 active registers: 16 data register and 2 process status register.

* ARM Core uses CPSR (Current Program Status Register):
CPSR → 32 bit register which resides in register file.
CPSR divided into 4 flags, each 8 bits wide.
Flags, status, Extension and Control.

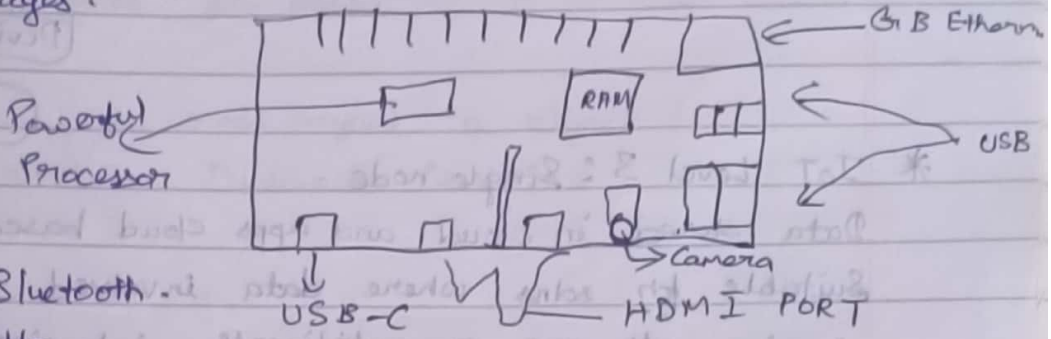


* Arduino: 8-bit ATmega328P MC. Consists of crystal oscillator, serial communication, voltage regulator, etc. 14 digital input/output pins (6 PWM outputs), 6 analog inputs, 16 MHz ceramic resonator, USB connection, power jack, ICSP header, reset button.



Each arduino has its own MC. It is brain of the board. Easy USB interface. Open source design. 32 Kb flash memory 13 digital pins, 6 analog pins. UNO, NaNO, Pro Mini, Mega 2560 are egs.

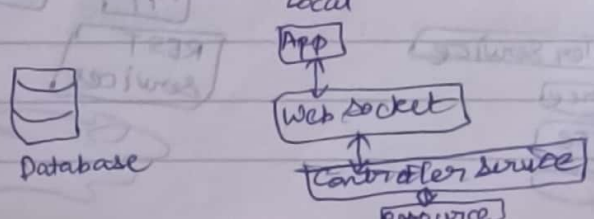
* Raspberry Pi : Mini Computer, low cost, size of credit card. Runs various flavors of linux. eg (Ubuntu, Arch, etc). Allows interfacing sensors and actuators. Supports many prog. languages.



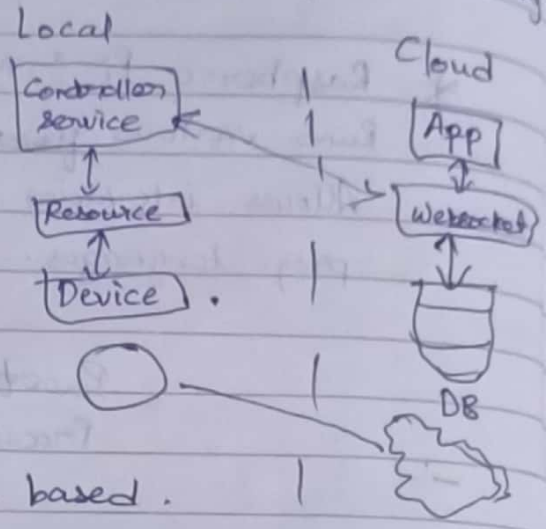
Inbuilt Wifi, Bluetooth. Speed 1.4 GHz. Micro SD Card. Many features even after being small in size. Consumes low power. Cost effective. Produced in large quantity.

* IoT — System of Interconnected computing devices, mechanical and digital machines, sensors, etc that have ability to share info with each other without human intervention. IoT devices think and adapt acc. to surroundings.

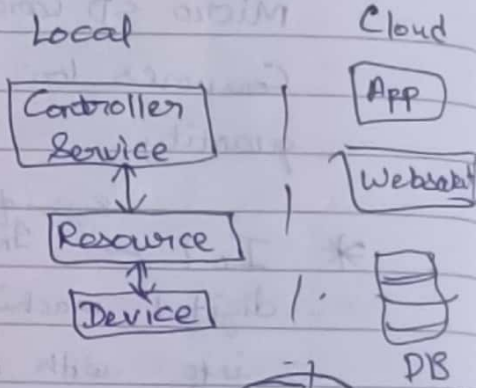
* IoT Levels :
Level 1 - has single device that performs sensing, actuation, store data, performs analysies, host application. Low Cost, Low complexity solns.



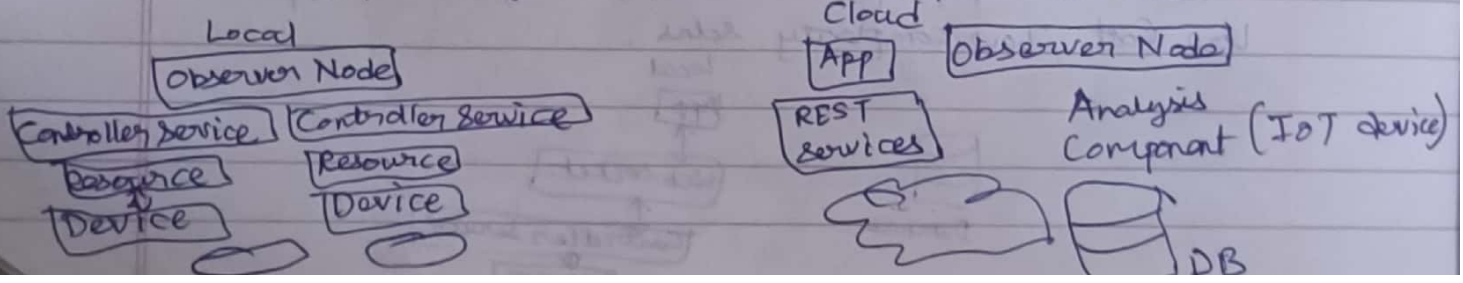
* IoT Level - 2 : Single node performs sensing, actuation and local analysis.
Data stored in cloud, application cloud-based.
Eg: Cloud based app is used for monitoring & controlling the system.



* IoT Level 3 : Single node.
Data stored in cloud and apps cloud based.
Suitable for solns. where data involved is big and analysis requirements are computationally intensive.



* IoT Level 4 : Has multiple nodes that perform Local Analysis
Data stored in cloud, apps cloud-based.
Level 4 contains local and cloud based observer nodes which can subscribe to receive info collected in the cloud from IoT devices.
Suitable for solns - where multi nodes required data big, analysis requirements comp. intensive.



Biometric Temp Press

BMP 280 — Pressure, Temp, Humi — Smart City, Smart Home

SCL - Clock Signal

ADC - Analog Digital Clock

Gas Smoke Sensor - Versatile sensor detects

MQ 2 - Heat driven sensor

Active and Passive IR Sensor

1. LED - continuously sends signal to object.

2. Ultrasonic Sensor - Distance Sensor

Transmitter Receiver

Chap 5.

Application Layer			
HTTP	CoAP	Websockets	
MQTT	XMPP	DDS	AMQP

Transport Layer	
TCP	UDP

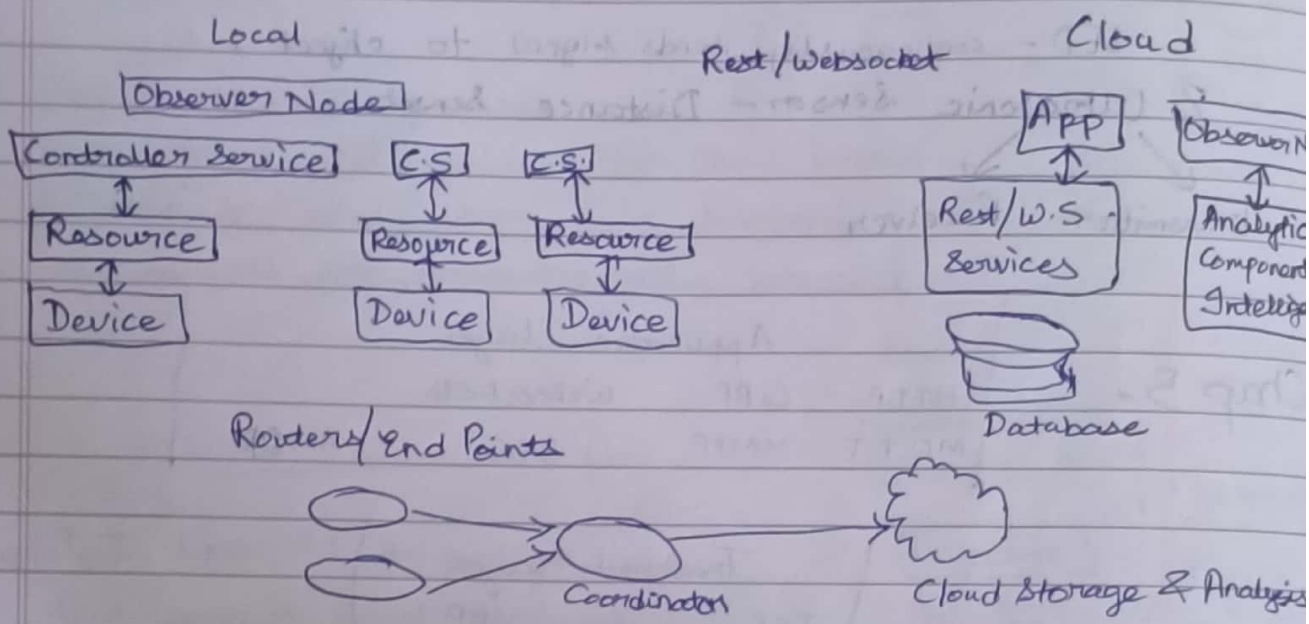
Imp. diagram

Can be asked

Network Layer		
IPv4	IPv6	6LoWPAN

Link Layer		
802.3 - Ethernet	802.16 - WiMax	2G/3G/LTE - Cellular
802.11 - WiFi	802.15.4 - LR-WPAN	

IoT Level 5 : ① Has multiple end nodes and 1 co-ordinator
② End nodes perform sensing / actuation.
③ The co-ordinator node collects data from end nodes and sends it to the cloud.
④ Data is stored and analysed in the cloud and app. is cloud based.
⑤ Level 5 IoT system are suitable for solutions based on wireless sensor networks, in which data involved is big and analysis req. are computationally intensive.



IoT Level 6 : ① Multiple independent end nodes.
② End nodes performing sensing / actuation and sends data to the cloud.
③ Data stored in cloud, app. cloud based.
④ Analytics component analyzes data and stored results in cloud D
⑤ Results are visualized with cloud based app. Centralized controller is aware of status of all end nodes and sends control commands to nodes.

* Types of Virtualization.

① Hardware : When VM software is directly installed on hardware system. After this process, different OS can be installed and different apps can be run on that OS. Hardware virtualization is done for server platforms bcoz handling VM is easier than controlling a server.

② OS : When VM software is installed on Host operating system instead of directly on hardware system. OS virtualization is used for testing apps on different platforms of OS

③ Server : When VM software is installed on server system. It is done bcoz a single server can be divided into multiple servers on demand basis and for balancing the load.

④ Storage : Process of grouping physical storage from multiple network storage devices so that it looks like a single storage device Done mainly for back-up and recovery process.

* Architecture of Cloud Computing

⇒ Front-End : • Used by client. • Contains client-side apps that are required to access cloud computing platforms. Includes web servers, clients, mobile devices, etc.

⇒ Back-End : • Used by service providers. • Manages all resources that are required to provide cloud computing services. • Include huge amount of data storage, security mechanism, VMs, deploying models, servers, etc.

- Software as a Service (SaaS) : Run directly through web servers means we don't require to download and install these apps.
  Eg : Google apps, Slack, Cisco Web Ex.

- Platform as a Service (PaaS) : Similar to SaaS, but difference is that PaaS provides a platform for software creation but using SaaS, we can access software over internet without need of platform. Eg : Windows Azure, OpenShift.

- Infrastructure as a Service (IaaS) : Responsible for managing apps, data, middleware and runtime environments.
  Eg : AWS, Google Compute Engine.

* Benefits of Cloud Computing.
  - Makes overall cloud computing simpler.
  - Improves data processing requirements.
  - Helps in providing high security.
  - Makes it more modularized.
  - Reduces IT operation costs.
  - Provides high level reliability.

Q. Edge Computing vs Cloud Computing

	Edge	Cloud
①	Most data-related processes occur locally.	① All data operations happen at a centralized location.
②	Low bandwidth required.	② High bandwidth required.
③	More expensive bcoz specalized software, hardware required.	③ Less expensive as users only pay for resources they use.
④	Apps that require low latency and real time decision making.	④ Apps that don't have strict latency requirements.
⑤	Eg : IoT devices, Autonomous vehicles.	⑤ Eg : Web apps, email, file storage

* Limitations of Edge Computing:

① Complexity: Setting up and maintaining the system is challenging.

② Limited Resources: Have constrained processing, storage, bandwidth which can restrict their capacity to carry out specific activities.

③ Dependence on Connectivity: In order for edge computing to work correctly, connection is required. If connection is lost, the system won't work.

④ Security concerns: Suspectible to security risks such as malware, hacking.

* Applications of Edge Computing in Industries

① Healthcare: Lot of IoT wearable devices - fitness trackers, heart beat monitors, etc. All these devices collect data every second and is then analyzed to gain insights.

② Transportation: Edge computing has lots of applications in this industry particularly self-driving cars. These autonomous cars require lots of sensors like 360° cameras, GPS, motion etc. If cloud based system is used here, then it may take a long time and cars can get crashed by hitting an object. To overcome this, edge computing is used as data can be analyzed from nearby data centers.

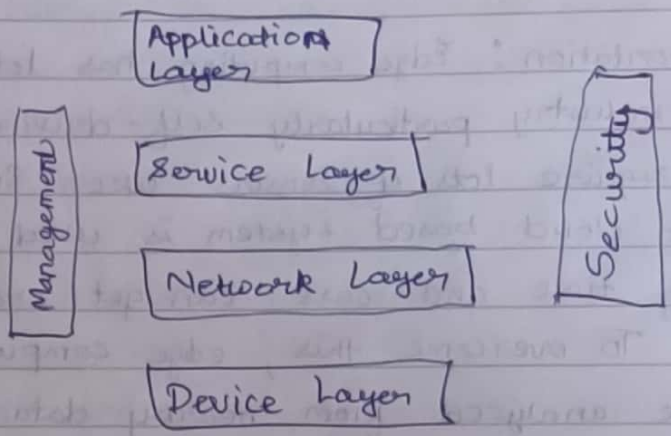
③ Retail: QR-apps. Motion sensors and cameras can be used to analyze what customer is buying.

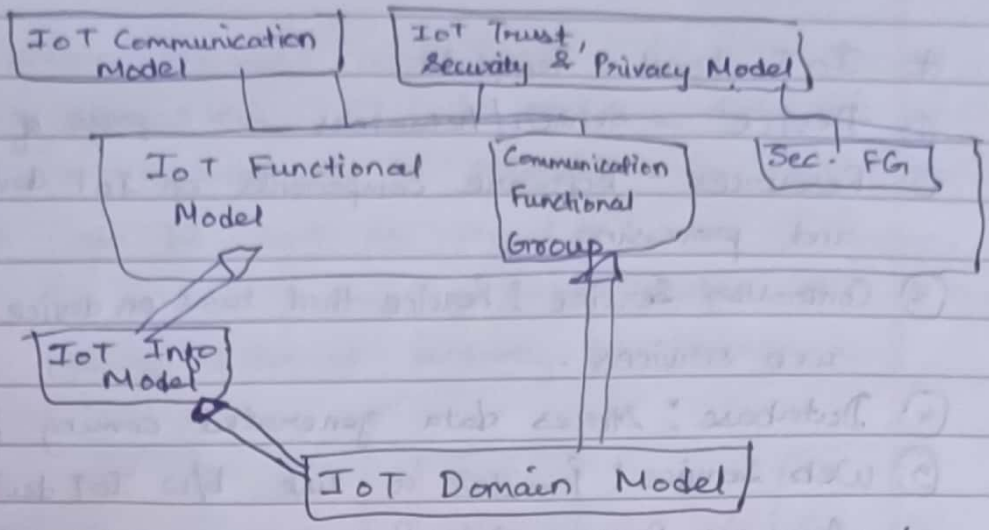
* Edge Computing Architecture

- Edge devices: A special purpose equipment with limited computing capacity.
- Edge node: Any device, server, gateway that performs edge computing
- Edge server: A computer located in facility close to edge device. These machines run applications workloads and shared devices, so they need more computer power than edge devices.
- Edge Gateway: An edge server that performs network functions such as tunneling, firewall management, wireless connections. A gateway can also host app. workloads.
- Cloud: Public/Private cloud that acts as repository for workloads like apps and ML models. Cloud also hosts and runs apps that manage edge nodes.

IoT Model and Protocal

* IoT Reference Model





- IoT domain model captures the basic attributes of main concepts and relationships b/w concepts.
- Domain model also serves as communication tool b/w people working across different domains.
- For IoT domain model, 3 types of devices are vital.

① Sensors: Simple / Complex devices → involve transducer → converts physical properties such as temperature to electrical signals

② Actuators: Simple / Complex devices → involve transducer → converts signals to physical properties (eg. turn on a switch).

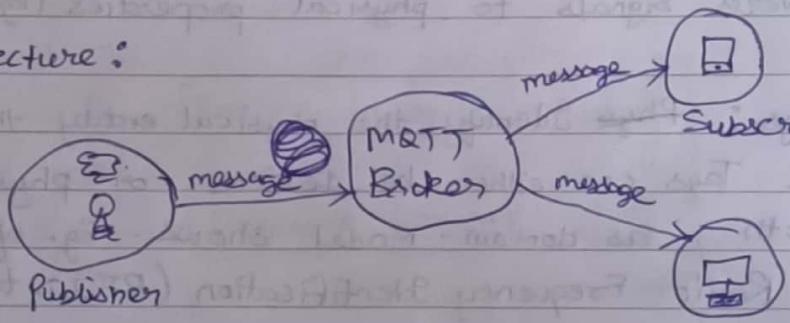
③ Tags: ~~Phys~~ Identify the physical entity they are attached to. Tags can either be devices or physical entity but not both, as domain model shows. Eg. of tag as a device is Radio Frequency Identification (RFID tag) whereas an eg. of tag as a physical entity is QR code.

* IoT Level Template

① Device – Sensor / Actuators → capable of identifying, sensing.
② Resources – Software components on IoT devices for accessing and processing.
③ Controller Service : Service that runs on device and acts with web services.
④ Database : Stores data generated coming from IoT devices.
⑤ Web Service : Provides a link b/w IoT devices, apps, DB.
⑥ Analysis Component : Performs analysis of generated data to make it easy for people to understand.
⑦ App. : Provides a system for user to view data.

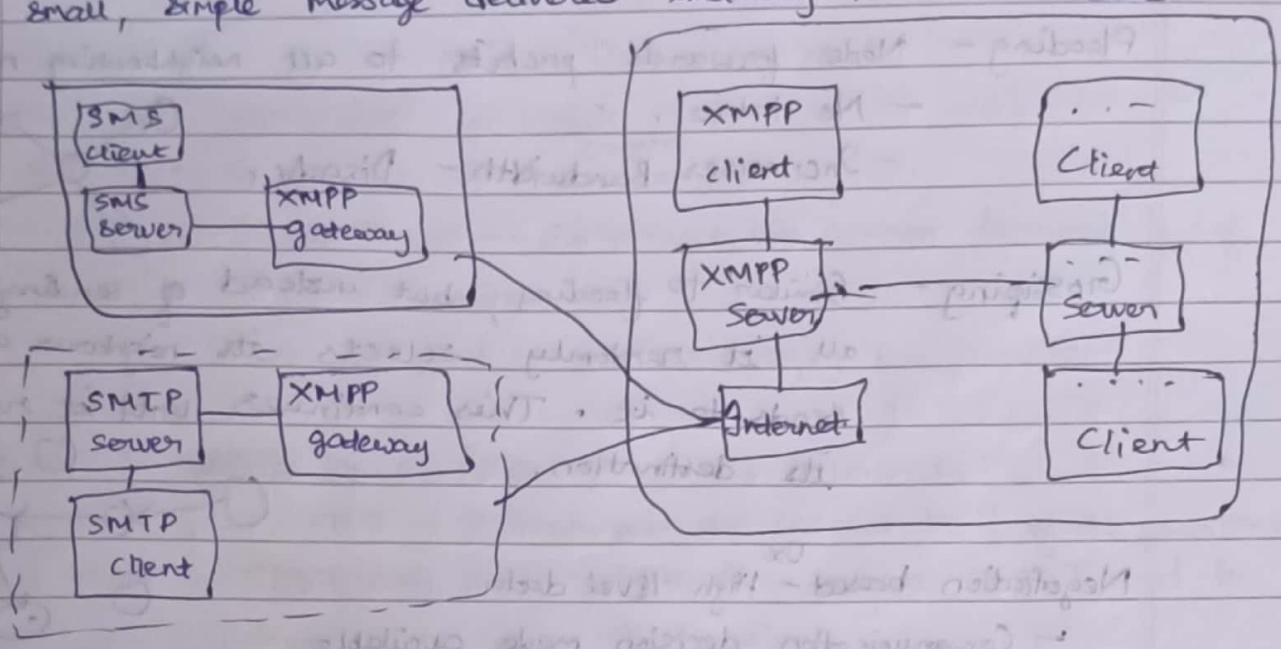
* MQTT : Message Querying Telemetry Transport.
Machine to Machine IoT connectivity protocol.
• Lightweight messaging protocol. • Useful for connection in remote location, where bandwidth is premium.
• Real Time messaging protocol. • Provide faster data transmission

MQTT Architecture :



• 4 components of MQTT architecture
1. Message : - Payload data, QoS, Collection of Problem, Topic Name
2. Client 3. Server / Broker 4. Topic

XMPP – Extensible Messaging and Presence Protocol. Used for building chat systems. Uses XML to exchange data b/w client and server. X: Protocol can be extended with new features. M: Messages can be sent as one-to-one or group. P: Presence, it shows contact's online states. Using this small, simple message delivered instantly to online users.



RTOS - Special purpose OS used in computer that has strict constraints to perform jobs. Employed where computation is used to influence a process.

Hard - All critical tasks must be operated within specified time. Else failure or loss.

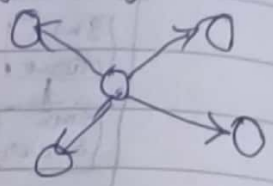
Soft - Accepts few delays. There may be closing date but delay is acceptable. Online transaction System.

Firm - Lacking a closing data might not affect system.

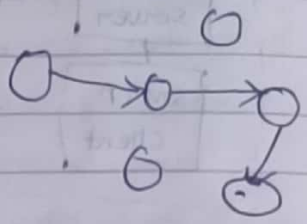
→ Adv: Easy to layout, less memory req. bcoz active Data Str. used. Max utilization of devices.

PROACTIVE	REACTIVE	HYBRID
Each node maintains separate routing table which contains all possible destination nodes. Updated periodically	On-demand routing protocols.	Mixture of both. Adaptive.

Flooding – Node forwards packets to all neighbouring nodes.
- No table.
- Increases Bandwidth – Disadv.



Gossiping – Similar to flooding, but instead of sending to all, it randomly selects its neighbour and sends to it. This continues until it reaches its destination.



Negotiation based – Use High level data
- Communication decision made available

SPIN – To solve issues of implosion and resource overlap, SPIN is used which negotiates before sending the data. Meta-data used to describe data. Each node has a resource manager.

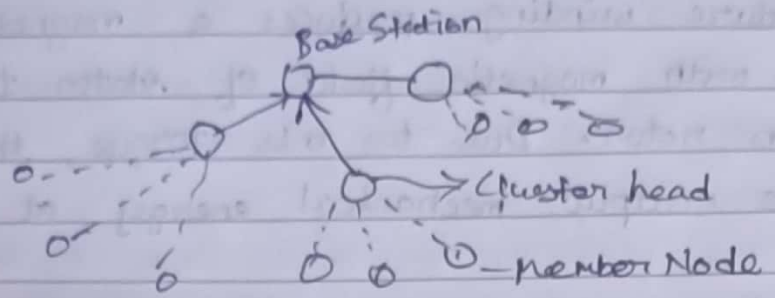
~~Address format~~

SPIN PP – Point to Point. Point (A, B) can talk to each other without interfering other nodes.

SPIN EC – When node observes that energy is below threshold it reduces its participation.

SPIN BC – Sends message to broadcast, so that all node receive. Uses a timer to check if it already received or requested the data.

Leach: Hierarchical Protocol that organizes clusters and energy is divided.



SPDT: Single Pole → One common Terminal
Double Throw → Can connect this common terminal to 1 of 2 other terminals.
Can control one circuit using two position.

DPDT: Double Pole → 2 sep terminals
DT → Each pole can connect to 1 of this common terminal
SPDT can only switch the output, DPDT used to change polarity at terminals.

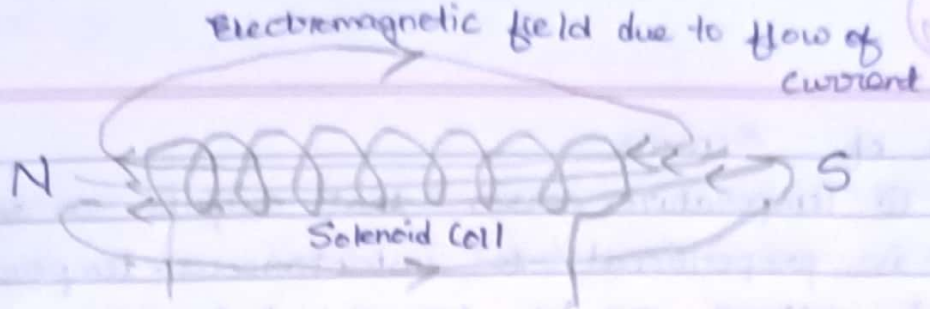
Actuator - Energy to action. Using signal. Responsible for physical movement.
Servo - When max output is required then servo. Gives max control. Signal in servo - either digital or analog. Feedback mechanism used. Speed ∝ Applied electric signal.

DC - Has two types of construction - brush and brushless. Two main parts: (i) Armature → Rotating part (ii) Stator → Stationary Part. Stator part forms the magnetic field system and the rotor part acts as armature of motor. A commutator is also mounted on shaft of rotor. The commutator segments are connected to ends of armature winding. In order to start the DC motor, a Direct Current

is allowed to pass into the armature window through the commutator and brushes. The current flowing through the armature winding produces a magnetic field which interacts with magnetic field of stator to produce a torque on rotor. Due to this torque, the rotor spins to produce output mechanical energy at the shaft.

* Stepper Motor – A type of brushless DC electric motor which divides a full rotation of shaft into a number of equal steps. Uses open-loop control system, i.e. it does not have any feedback mechanism. Rotor of stepper motor is a permanent magnet rotor. In case of a stepper motor, the electrical input to stator winding of motor produces an output in form of discrete angular rotation of rotor. The discrete ~~motion~~ rotation is produced in such a way that when stator winding is energized, a step by step current flows through the winding sequentially thereby magnetizing the stator.

* Solenoid : When a metallic wire (usually copper) is wound in a loop in circular fashion it is called solenoid. When an electric current is passed through the coil, an electromagnetic field is created that provides energy for linear motion. Solenoid coils are one of the simplest forms of linear actuation devices. A solenoid works by producing electromagnetic field around a movable core, called an armature. When compelled to move by electro-magnetic field, the motion of armature opens and closes valves or switches and turns electrical energy into mechanical motion and force.



The benefit of a solenoid coil, when compared to a magnet, is the fact that it can be turned off, that makes it perfect for switches, valves and automated devices.

* Sensors : A sensor measures some physical quantity and converts that measurement reading into a digital representation. That digital representation is passed to another device for ~~info~~ transformation into useful data that can be consumed by humans / devices. Sensor are classified in various groups.

① Passive and Active.

(i) Passive : Can't sense the input independently. Eg : Soil moisture water level, temperature sensor.

(ii) Active : Independently senses the input. Eg : Radar.

② Analog and Digital.

(i) Analog : The response of sensor is some continuous function of its input parameter. Eg : Analog Pressure Sensor.

(ii) Digital : Gives response in binary nature. Designed to overcome disadvantages of analog sensor. Eg : Digital Temperature Sensor.

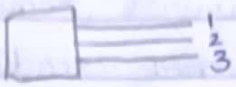
③ Scalar and Vector.

(i) Scalar : Detects the input parameter only based on magnitude. Eg : Gas, smoke sensor.

(ii) Vector : The response of sensor depends on magnitude of direction and orientation of input parameter. Eg : Motion detector sensor.

⇒ Types of Sensors

- LM35 : ① Temperature sensor that outputs an analog signal which is proportional to instantaneous temperature.
② Output voltage can be interpreted to obtain temperature (in °C).
③ Advantage of LM35 is that it doesn't require any external calibration.
④ Coating also protects it from self-heating.



1 ⇒ 4 - 30 V
2 ⇒ OUT
3 ⇒ GND

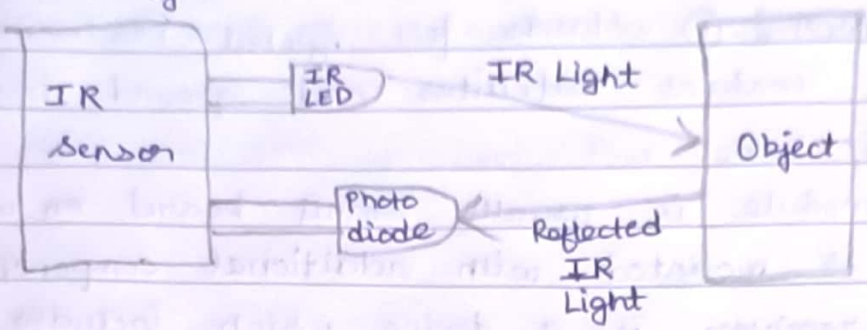
⑤ Operates from 4 V to 30 V.

- BMP 280 : ① High precision sensor that measures atmospheric pressure and air humidity. It supports both SPI and IIC interface.
② These sensors are calibrated from the start.
③ They can start measuring pressure, humidity as soon as they are turned on.
④ It is so tiny that it can be used on a mobile.
⑤ BMP 280 is also used to measure altitude.

- MQ-02/05 (gas/smoke : ① Can detect LPG, smoke, CO concentrations in air.
② This makes it an excellent choice for building air quality monitoring system.
③ It is a MOS (Metal oxide Semiconductor) sensor.
④ MOS are also known as Chemiresistors bcoz sensing is based on change in resistance of sensing material when exposed to gases.
⑤ Covered with 2 layers of fine stainless steel mesh known as anti explosion network.

- Obstacle Sensor : ① IR sensor is an electronic device that emits light in order to sense some object of the surrounding.

② An IR sensor can measure heat as well as motion of an object.



- Ultrasonic Sensor : ① Usually consists of 2 ultrasonic transducers.

② One acts as a transmitter that converts electric signal into ultrasonic sound pulses.

③ Other acts as a receiver and listens for transmitted pulses.

④ When the receiver receives these pulses, it produces an output pulse.

⑤ The width of received output pulse is proportional to distance of object in front.

⑥ width of received pulse is used to calculate the distance from reflected object.

- Gyro Sensor : ① Also called angular rate sensor.

② These sensor are used where orientation of object is difficult to sense by humans.

③ Measured in degrees per second, angular velocity is change in rotational angle of object per unit time.

④ Besides sensing the angular velocity, Gyro sensors also measure motion of object.

⑤ Gyro sensors used in variety of applications. Eg: Car navigation system, robotic systems.

* GPS sensor: ① Stands for Global Positioning System.
② System contains satellites and ground based control installations.
③ GPS module is usually small board on which GPS sensor is mounted with additional components.
④ GPS receiver is a device which includes data display and data storage unit.
⑤ GPS contains 3 segments: (i) Space (ii) Control (iii) User.

* LDR Sensor: ① Stands for Light Dependent Resistor
② Type of resistor that works on photoconductivity principle means that resistance changes according to intensity of light.
③ Resistance decreases with increase in intensity of light.
④ LDRs are usually available in 5mm, 8mm, 12mm, 25mm dimensions.
⑤ When light falls on its photoconductive material, it absorbs its energy and e^-s of photoconductive material in the valence band get excited and go to the conduction band and thus increasing the conductivity as per the increase in light intensity.
⑥ Also, the energy in incident light should be greater than bandgap energy so that e^-s from valence band get excited and go to conduction band.

* Tiny OS : ① A component based open source OS.
② Fundamental language is nesC, a version of C programming language.
③ It is designed for wireless sensor networks.
④ Tasks are non-preemptive and run in FIFO order.
⑤ Has different models and each model performs its own unique task.
⑥ Needs low memory and low voltage.

* Contiki OS : ① Free and open source OS.
② Used for connecting low-power, low cost microcontrollers to the net.
③ Designed to adhere highest internet standards, such as full support for IPv4 & IPv6.
④ written in C language to provide rapid programming event.
⑤ Powers down when network is inactive.

* CoAP : ① Stands for Constrained Application Problem.
② Used for dealing with constrained devices (microcontrollers) and constrained networks in IoT.
③ It is a M2M (machine to machine) app used in smart energy.
④ Client, Server, Endpoint, Sender, Receiver.
⑤ Uses both sync and async messaging.

* AMQP : ① Stands for Advanced Message Querying Protocol.
② It is an open standard app layer protocol for message-oriented middleware.
③ Mostly used in banking servers and apps.
④ Uses TCP for reliable communication.
⑤ Follows publisher subscriber model for communication.

* 6LOWPAN :- ① Stands for IPv6 over Low Power Wireless Personal Area Network.
② Low cost, short range, low message usage.
③ Comprises of edge router and sensor nodes.
④ Using 6LoWPAN, the smallest of the IoT devices can be part of the network and talk to outside world.
⑤ 6LoWPAN uses AES - 128 link layer security. It provides link authentication and encryption.

* Characteristics of IoT

- Connectivity - Important requirement of IoT infrastructure. Things of IoT should be connected to the IoT infrastructure. Anywhere, anytime should be able to connect.

- Intelligence - The extraction of knowledge from generated data is very important. Each IoT device has a unique identity. This identity helps in tracking the equipment and for querying its status.

- Scalability - The number of elements connected to IoT zone is increasing day by day. Hence, IoT setup should be capable of handling the massive expectations.

- Dynamic and Self Adapting : IoT devices should dynamically adapt themselves to changing contexts.

* IoT Layers.

1. ① Layer 1 (Sensor Layer): This layer is concerned about physical components mainly sensor.
② PLC, actuators, etc are considered in physical layer.
③ Layer responsible for data collection.

2. ① Layer 2 (Processing and Control Action Layer): Comprises of core components for IoT.
② Data is received by microcontrollers from sensors.
③ Various OS like Android, Linux, IOS execute the tasks.
④ Data collected from sensors is processed.

3. ① Layer 3 (Hardware Interface Layer): Hardware components and communication standards such as RS 232, CAN, SPI, SCI occupy this layer.
② All these components ensure flawless communication.

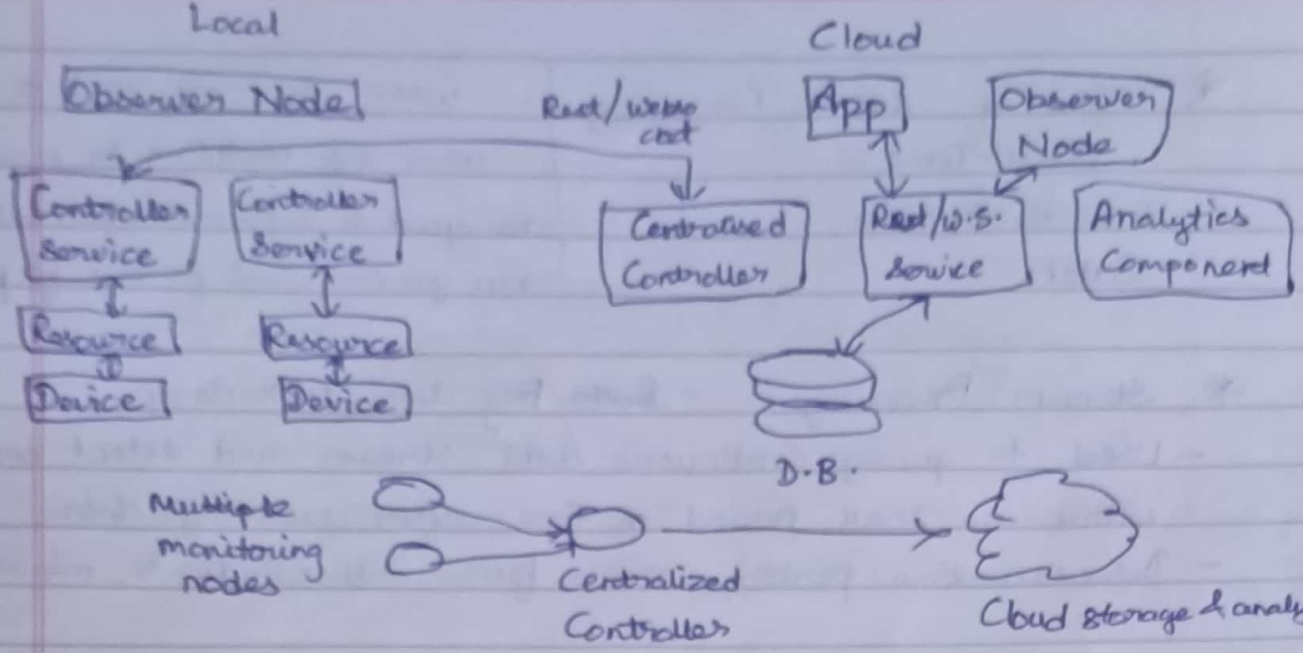
4. ① Layer 4 (RF Layer): Plays a major role in communication channel - short / long range.
② Common protocols used are WiFi, NFC, RFID, bluetooth.

5. ① Layer 5 (Session / Message Layer): Session Management is important. Guided by OSI Layer.
② There are protocols which see how messages are brodcasted to cloud.
③ CoAP, MQTT are protocols used.

6. ① Layer 6 (User experience): Fully concerned with user experience.
② Product designed should have Rich UI features and designs.
③ OOPs languages, scripting language should be included.

7. ① Layer 7 (Application layer): Everything comes to perfection in this layer.

② This layer talks about all possible apps that can be built with help of other layers.



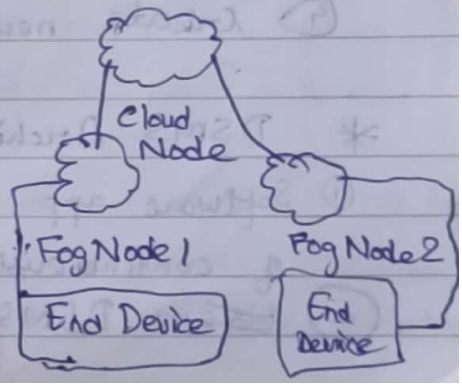
Cloud Computing: Here, data is processed on a central cloud server, often located far from its source.

Fog Computing: Data processed within fog nodes or IoT gateway in LAN. (when only selected data is required to send to cloud)

Edge Computing: The data is processed on device or sensor itself. It does not require shifting to any other location.

Fog Computer Architecture

- Fog Computer term coined by Cisco refers to extending cloud network.
- Used when data should be analysed within fraction of seconds.
- Facilitates operation of computing, storage, and networking services b/w end device and computing data centers.
- Used when only selected data is required to send to cloud.
- Used when large number of services need to be provided over a large area at different geographical locations.



Type of data Processing	When do you need it
Real-Time	When info needed to be processed immediately
Near real-time	When speed is important, but don't need immediately
Batch	When you can wait for days for processing

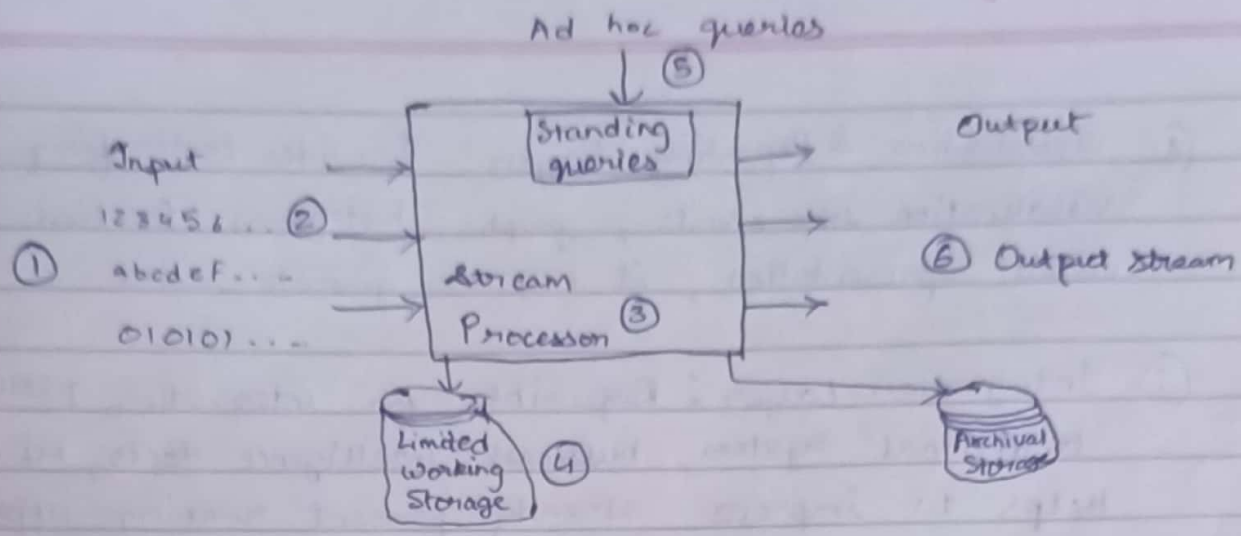
* Stream Processing : - ~~Bacth~~ Big data technology.
  - Used to query continuous data stream and detect condition within a small period of time after receiving data.
  - Detection time period varies from milliseconds to minutes.

* Stream data : ① Data generated continuously. ② Coming from many sources. ③ Sends data in small size (~~K~~bs).

DBMS	DSMS
① Persistent Data	① Stream Data
② Data access — random	② Data access — sequential
③ Query provides exact answer	③ Query provides approx answer.
④ Uses unbounded disk store.	④ Uses unbounded main memory.
⑤ Queries are one-time.	⑤ Queries are continuous.
⑥ No-real time requirements	⑥ Real time requirements.

* Stream processing is needed for :
  ① Developing adaptive and responsive apps.
  ② Facilitate faster decisions.
  ③ Improve user experience.
  ④ Create new apps that use a wide variety of data sources.

* DSMS Architecture
  ① Software app just like DBMS but involves processing and management of continuously flowing data.
  ② ~~Uses~~ DSMS process 2 types of queries : ① Standard queries ② HoC queries.



- Standing Queries: Asked to stream at all times.
- Ad-Hoc Queries: Asked one time to the stream.

* Layers of DSMS

(1) Data Source Layer: First layer of DSMS and comprises of all data sources which includes sensors, social media feeds, financial market, etc. Capturing and parsing of data happens.

(2) Data Ingestion Layer: Bridge b/w data source layer and processing layer. Handles the flow of data. eg. data Buffering

(3) Processing Layer: Heart of DSMS architecture as it is the functional layer. Processes the data streams in real time. Main function of this layer is to filter, transform, aggregate the data stream.

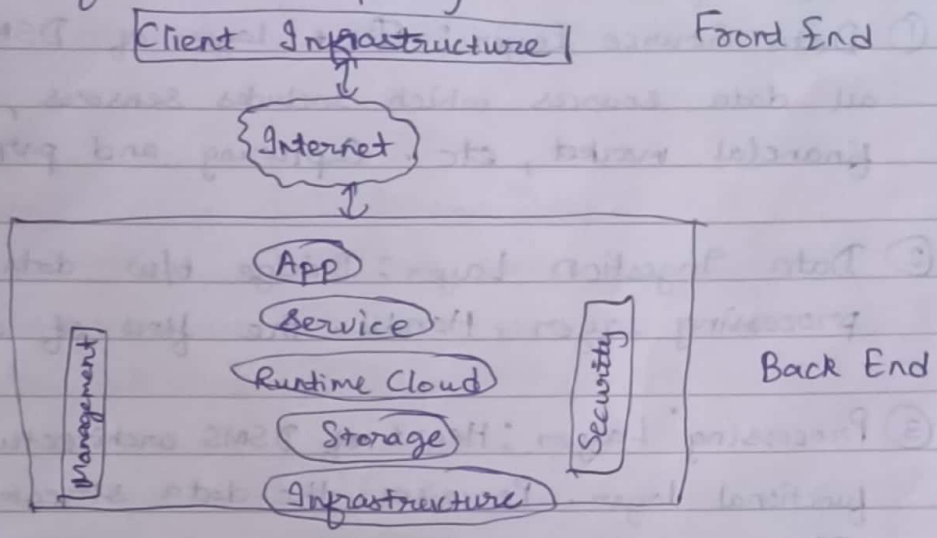
(4) Storage Layer: Once data is processed, we need to store it in any storage unit. Consists various storage like NoSQL DB, distributed database. Helps to ensure data durability and availability in case of system failure.

(5) Querying Layer: 2 types of queries supported - standard & ad hoc. Provides tools which can be used for analysing data streams. Queries can be: How many data inserted? What type of data

⑥ Vizualisation & Reporting Layer: Provides tools for performing visualization like charts, graphs, histograms. On basis of visual representation, it helps to generate report.

⑦ Integration Layer: Responsible for integrating DSMS app with traditional system, business intelligence tools, ML apps. Helps to improve already present running apps. Provides scalable apps which can handle huge ~~amount~~ volume of streaming data.

* Architecture of Cloud Computing



* Virtualization in Cloud Computing.

- A technique which allows to share a single physical instance of a resource among multiple customers.
- Creation of VM over existing OS and hardware is Hardware Virtualization.
- VM provides an entertainment that is logically separated from underlying hardware.
- Machine on which VM is going to create is Host Machine and VM is referred as Guest Machine.